An Atlas of Nutrient Deficiency Symptoms in *Hibiscus rosa-sinensis*

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Abstract

Deficiency symptoms of essential nutrient elements were induced in *Hibiscus rosa-sinensis* in a nutrient-omission trial in acid-washed sand. An atlas of deficiency symptoms was presented with description on individual deficiency symptoms. Dry matter of above- and below-ground parts from control and deficient plants as well as their foliar elemental contents were determined and compared.

Introduction

Hibiscus is noted for its colourful and attractive flowers. Owing to this trait, it is highly regarded as a candidate for hedges, road-side planting and landscape in parks, gardens and private homes.

In recent years, the Singapore Botanic Gardens has initiated a breeding programme for *Hibiscus* resulting in the procreation of an array of hybrids with great ornamental value. After screening their potential, selected hybrids are being introduced for mass planting. There is, therefore, a need to better understand the nutrition of *Hibiscus*. Nutrient deficiency symptoms have only been scantily described without specific reference to *Hibiscus* (Anonymous 1979; Chin, 1986; Beers & Howie, 1986 and Howie, 1980). The nutrient-omission trial was to establish the nutrient deficiency symptoms in *Hibiscus rosa-sinensis* so as to provide a useful cross reference for deficiency symptoms in the wide spectrum of possible hybrids. This would enable *Hibiscus* breeders, growers and enthusiasts alike to trouble-shoot nutritional problems in *Hibiscus*.

Materials and Methods

Sand was loaded onto a fine sieve and washed continuously with tap water to rid soluble salts, silt, clay and other colloidal materials. Sand free of fine particles was leached several times with IN HCl to remove adsorbed ions if any and rinsed with deionised water to remove all residual acid. Plastic pots, approximately 20 cm in diameter and 25 cm deep, were packed with the treated sand.

Uniform bag-grown *Hibiscus* plants about 1 m tall were selected. The root systems were bared carefully and washed free of all soil contaminants. After rinsing with deionised water, they were transplanted into the pots of sand. The potted plants were left to establish under shade for a few days before being exposed to full sun in an open cement ground.

Liquid nutrient formulations were according to Foong et al. (1982). Salinity of

each liquid feed was checked and the pH adjusted to 5–5.5 with dilute HCl before application. The control was raised with a complete nutrient feed whereas each treatment was fertilised with a nutrient feed lacking the nutrient element in question. Treatments and control were replicated six times. Fertilising was carried out every alternate day at the rate of 200 ml per pot, the amount required to soak the pot completely. On other days, 200 ml of deionised water was added to each pot.

Deficiency symptoms were recorded photographically as they became evident. After 6 months, trial plants were harvested and divided into leaf, stem and root. There was no flowering over the trial period. The three fractions were washed free of contaminants. The foliar fraction was further subdivided into the mature and young portions, washed with a non-ionic detergent and rinsed several times with deionised water. All plant samples were dried at 80°C until constant weight for dry matter analysis. Young and mature foliar samples were subjected to elemental analysis. The mature fractions were used for the analysis of mobilisable nutrient elements while the young fractions were used for the analysis of non-mobilisable nutrient elements.

Total nitrogen was determined by the micro-Kjeldahl method, phosphorus by the vanadate-molybdate-yellow method after dry ashing with magnesium nitrate, boron by the Azomethine-H method after dry ashing with calcium oxide, and the remaining elements by atomic absorption using the PU9000 Spectrometer after dry ashing and dissolution of ash in dilute HCl (Cantle 1982; Chapman & Pratt 1961 and Evenhuis 1978). Sulphur and molybdenum were not determined.

Results and Discussions

Results of dry matter analysis and elemental analysis are tabulated in Table 1 and Table 2 respectively. Statistical inference was based on the least significant difference (Gomez & Gomez 1976). Nutrient deficiency symptoms are presented in Plates I to VII and described as follows:-

(a) *N Deficiency*

Deficient plants were dwarfed. Leaves were very much reduced in size compared with the counterparts of the control. Uniform chlorosis became evident initially on the older leaves and slowly spread to the younger leaves in advanced deficiency. Even the veins became chlorotic, giving a total chlorotic appearance (Plate I). Premature leaf fall was common. Dry matter production of above- and below-ground parts was significantly reduced in N deficiency (Table 1). Foliar analysis showed a distinct difference in the N content between control and deficient plants (Table 2).

(b) *P Deficiency*

Leaf size was not affected and deficiency symptoms were only mildly expressed over the 6-month trial period. Deficient plants became slightly chlorotic with chlorosis concentrating along the leaf margin (Plate II). Overall dry matter production was curtailed (Table 1). Foliar P was markedly reduced in deficient plants (Table 2) and should be used in conjunction with foliar symptoms to confirm P deficiency in *Hibiscus*.

(c) *K Deficiency*

There were little tell-tale signs of K deficiency except for minor marginal chlorosis as in the case of P deficiency (Plate III). Leaf size and plant growth were altogether unaffected (Plate III and Table 1). However, there was a

pronounced reduction in foliar K (Table 2) and diagnosis of K deficiency should be based on measurement of this parameter.

(d) *Ca Deficiency*

Symptoms were manifested as chlorosis in the young leaves followed by necrosis, culminating in the die-back of growing tips (Plate IV). Gradually, the deficient plants assumed a rather bare appearance. Both the foliar Ca content and dry matter of affected plants were significantly lower than those of the healthy control plants (Tables 1 & 2).

(e) *Mg Deficiency*

In early Mg deficiency, the mature leaves exhibited yellow spotting mainly in the middle of the lamina. As deficiency progressed, the yellow spots linked to form chlorotic patches. Eventually, the whole blade became chlorotic with the main veins retaining a light green tinge (Plate V). Reduction in the foliar Mg content in Mg-deprived plants was associated with smaller leaves and subdued growth (Tables 1 & 2).

(f) *Fe Deficiency*

Fe deficiency symptoms were characterized by interveinal chlorosis on the young leaves especially on the newly-emerged leaves, resulting in a very distinct "netting" effect (Plate VI). However, Fe contents in healthy and deficient

Table 1
Dry weights of above- and below-ground parts

Treatment	Dry matter of above-ground parts (g/pot)	Difference from Control	Dry matter of below-ground parts (g/pot)	Difference from Control	Total Dry Matter (g/pot)	Percentage Difference from Control
Control	80.59		14.05		94.64	
– N	31.79	(48.8)**	9.14	(4.91)*	40.93	(56.75)
– P	52.79	(27.82)*	9.13	(4.92)*	61.90	(34.59)
– K	67.07	(13.52)	12.13	(1.92)	79.20	(16.31)
– Ca	35.56	(45.03)**	7.21	(6.84)**	42.77	(54.81)
– Mg	36.54	(44.05)**	5.76	(8.29)**	42.30	(55.30)
– Fe	109.03	28.44	22.70	8.65	131.73	39.19
– S	114.30	33.71	17.73	3.68	132.03	39.51
– B	50.77	(29.82)**	7.21	(6.84)**	57.98	(38.74)
– Mn	121.93	41.34	21.18	7.13	143.11	51.22
– Cu	104.83	24.24	16.12	2.07	120.95	27.80
– Zn	125.32	44.73	21.71	7.66	147.03	55.36
– Mo	137.50	56.91	19.14	5.09	156.64	65.51

Values tabulated are the averages of 6 replicates
Bracketed values are below those for the control
* Significant at P = 0.05
** Significant at P = 0.01

Plate I: Foliar symptoms of N deficiency

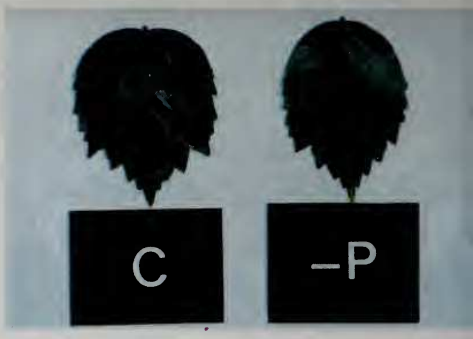

Plate II: Foliar symptoms of P deficiency

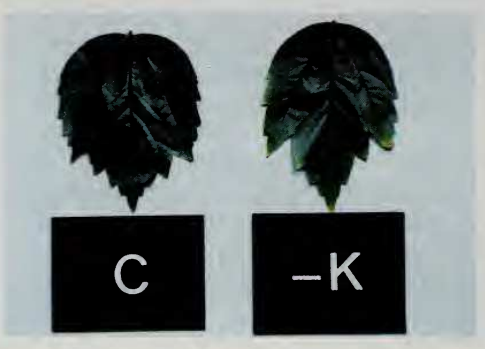

Plate III: Foliar symptoms of K deficiency

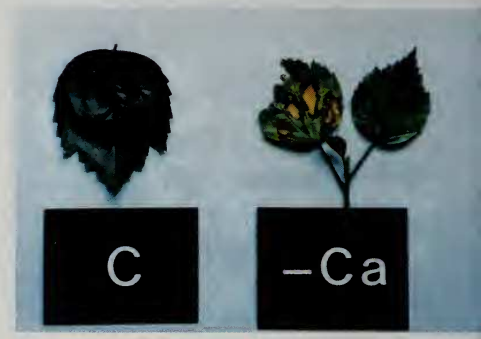

Plate IV: Foliar symptoms of Ca deficiency

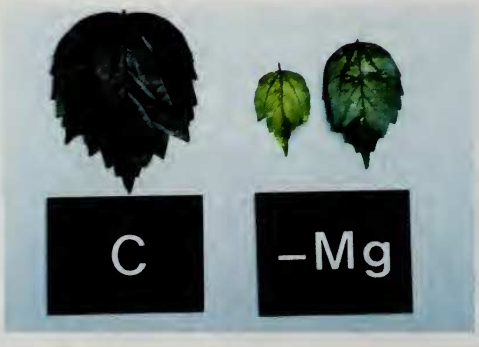

Plate V: Foliar symptoms of Mg deficiency

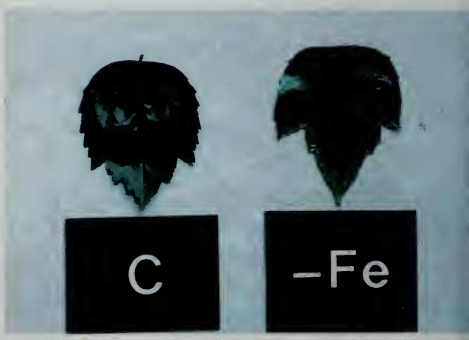

Plate VI: Foliar symptoms of Fe deficiency

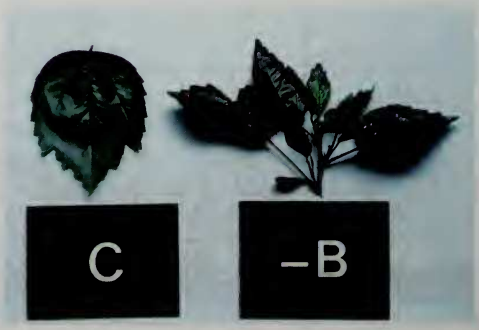

Plate VII: Foliar symptoms of B deficiency

Key: C connotes control

Table 2
Foliar elemental contents in deficient and control *Hibiscus*

Treatment	Control mean for mature foliage (%)	Treatment means for mature foliage (%)	Difference from control (%)
– N	3.96	2.88	(1.08)**
– P	0.49	0.22	(0.27)**
– K	2.60	0.63	(1.97)**
– Mg	0.51	0.22	(0.29)*
Treatment	**Control mean for young foliage (ppm)**	**Treatment means for young foliage (ppm)**	**Difference from control (ppm)**
– Ca	12450	215	(12235)**
– Fe	173	137	(35)
– B	51	30	(21)**
– Mn	188	31	(157)**
– Cu	8	3	(5)**
– Zn	137	163	26

Values tabulated are the averages of 6 replicates
Bracketed values are below those for the control
* Significant at P = 0.05
** Significant at P = 0.01
Deficient levels of elements do not necessarily connote the critical values at which symptoms just begin to appear.

young leaves were similar (Table 2). It has been reported that iron chlorosis in a number of plant species could only be resolved by examining the "active Fe" fraction instead of the total Fe content (Foong & Yang 1987 and Takkar & Kaur 1984). *Hibiscus* may well fall into this category. Dry matter accumulation was also unaffected over the period of the trial (Table 1).

(g) *Boron Deficiency*

B deficiency symptoms were manifested at the growing points by a marked reduction in the size of young leaves and very much shortened internodes, generating the "rosette" appearance (Plate VII). Both dry matter and foliar B were adversely affected by B deficiency (Tables 1 & 2).

No characteristic deficiency symptoms were induced in the omission of S, Cu, Zn, Mn or Mo. In these cases, deficient plants performed as well as the control plants (Table 1). Traces of these elements as remaining contaminants in the sand even after cleansing could have sustained normal growth over the 6-month trial period. Conversely, this finding may be taken to imply that *Hibiscus* is not very sensitive to the deficiency of these trace elements. Nevertheless, plants deprived of Cu or Mn did show a reduction in the foliar level of the element omitted (Table 2).

Conclusion

Deficiency symptoms of N, P, K, Ca, Mg, Fe and B were successfully induced in *Hibiscus rosa-sinensis* cultured in sand and further confirmed by foliar analysis. The characteristic symptoms of N, Ca, Mg, Fe and B deficiency can be employed with a high degree of certainty as diagnostic tools. Symptoms of suspected P or K deficiency are, however, best ascertained by foliar analysis.

Fe deficiency is by far the most commonly observed in field- and pot-grown *Hibiscus* as a result of overliming or inadvertent overdoses of phosphatic fertiliser.

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